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RESEARCH MEMORANDUM

for the

David Taylor Model Basin, Department of the Navy

ROUGH-WATER TESTS OF MODELS OF THE VOSPER

AND PLUM PLANING BOATS

By Derrill B. Chambliss and Ulysse J. Blanchard

Langley Aeronautical Laboratory
Langley Air Force Base, Va.

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Author: *NACA R7 2972* Date: *3/17/57*

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NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
WASHINGTON
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ROUGH-WATER TESTS OF MODELS OF THE VOSPER
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SUMMARY

Models of two types of high-speed surface craft were tested in Langley tank no. 1 to obtain rough-water data for an evaluation by the David Taylor Model Basin of the relative merits of the designs. Time-history records were obtained of trim, rise, and normal acceleration at two points in the hulls for various speeds and two sizes of waves.

INTRODUCTION

Rough-water tests of two $\frac{1}{8.5}$ -size models of the Vosper and Plum high-speed planing boats were made in Langley tank no. 1 at the request of the David Taylor Model Basin, Department of the Navy. The purpose of the tests was to obtain comparative information regarding the rough-water characteristics of the models for use of the David Taylor Model Basin in evaluating the relative merits of the two designs.

Messrs. John Plum and Eugene P. Clement of the Planing-Forms Group of the Model Basin witnessed the tests and advised as to necessary changes made in the models and test program.

SYMBOLS

g acceleration due to gravity, 32.2 feet per second per second
n normal acceleration, g units

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- τ trim (angle between base line and horizontal), degrees
- r rise (vertical displacement of towing point), inches. (The rise of the model was considered zero with the model at rest in smooth water. In this static condition the draft of the Vosper design was 4.1 inches and the draft of the Plum design was 5.1 inches.)

DESCRIPTION OF MODELS

The Vosper design, designated Langley tank model 272, is shown as figure 1; the Plum design, designated Langley tank model 273, is shown as figure 2. The positions of the center of gravity, the towing point, and the accelerometers for models 272 and 273 are shown in figures 3 and 4, respectively. The base line of the Vosper design (fig. 3) is parallel to the inner bottom; the base line of the Plum design is parallel to the deck line aft of station 4. In order to prevent water from entering the models during runs in waves, the spray strips shown in figures 3 and 4 were installed at the deck line. The strips were of sheet aluminum, 1.5 inches wide, and bent down approximately 30° .

The models, furnished by the David Taylor Model Basin, were of built-up wood construction and were ballasted to obtain the scale gross weight and the center-of-gravity positions shown in figures 3 and 4. The moments of inertia of the ballasted models about these centers of gravity were determined by swinging as compound pendulums and are as follows:

Model 272	36.3 slug-feet square
Model 273	45.1 slug-feet square

The stabilizer on model 273 (fig. 2) was attached to a piston and held in a retracted position by a stiff spring within the piston cylinder mounted inside the hull. To project the stabilizer below the keel, compressed air was used to force the piston down in the cylinder. Vertical motion was limited by stops. Settings of these stops and adjustment of the air pressure for stabilizer positioning were made by Mr. Plum. The positions corresponded to those used in the smooth-water investigation at the David Taylor Model Basin.

APPARATUS

The tests were made in Langley tank no. 1, which is described in reference 1. The towing gear used for investigations of flying-boat models in rough water was used and is shown in figure 5. The models were free to trim about a pivot located at the lower end of a rectangular towing staff. This staff was free to move vertically in a roller cage which, in turn, was free to move fore and aft relative to the towing carriage. The models were restrained laterally and in roll and yaw. To further limit yaw, each model was equipped with a 4-foot sting of steel tubing which was free to move vertically between guides rigidly fixed to the carriage.

Towing force was applied through a long coil spring attached to the roller cage. Tension in the spring was adjusted by a cable and winch arrangement. When running in waves, the spring allowed the models to move fore and aft relative to the carriage with only small changes in the towing force. A second spring attached to the rear of the roller cage restrained the models during rapid deceleration of the towing carriage. The mass moving fore and aft was greater than that moving vertically by an amount equal to the weight of the roller cage, approximately 13 pounds.

The trim and vertical position of the model together with the fore-and-aft position relative to the carriage were recorded by means of slide-wire pickups. Wave profiles were recorded by two vertical struts immersed in the water ahead of and behind the model. The struts were displaced laterally to avoid interference of their wakes and the wake of the models. The accelerometers, mounted parallel to the base line on a line through the pivot, recorded normal accelerations at points 32.2 percent and 44.2 percent of the model lengths forward of the transom. The accelerometers were strain-gage instruments having natural frequencies of 180 cycles per second and were damped to 0.7 of the critical value. Output from the accelerometers was amplified and fed into oscillograph galvanometers which had a natural frequency of 30 cycles per second and were also damped to 0.7 of the critical value. In the static condition, the accelerometers read zero.

PROCEDURE

Both models were ballasted to a displacement of 161.0 pounds, corresponding to 158.5 pounds in fresh water, to obtain the static trim corresponding to that of the smooth-water tests at the David Taylor Model Basin. The static trims of the Vosper and Plum models were 1.0° and 0.5° , respectively. With this ballast, the center of gravity was determined to be 11 inches aft of station 5 and 2 inches above the inner bottom for the Vosper model, and 8.4 inches aft of station 4 and 6.9 inches below the deck line for the Plum model. The towing points were initially located at these center-of-gravity positions.

In preliminary tests the running trims of the Vosper model were found to be low as compared to those obtained during the previous smooth-water tests. In order to reproduce the running trims of the David Taylor Model Basin tests, the center of gravity was shifted, by repositioning the ballast, to a point 14.1 inches aft of station 5 as shown in figure 3. The static trim was then 1.6° and the towing point did not coincide with the center-of-gravity position.

At the request of Mr. Plum, the towing point of the Plum model was lowered to the position shown in figure 4. The static trim of the Plum model remained at 0.5° .

The models were tested at constant speeds of 15, 23, 30, and 37 feet per second in waves $3\frac{1}{2}$ inches in height and approximately 24 feet in length and at speeds of 15, 23, and 30 feet per second in waves $4\frac{1}{2}$ inches in height and approximately 17 feet in length. For each run, records of the variation in vertical position of the towing point, trim, and fore-and-aft position relative to the towing carriage, normal accelerations, wave profiles, and speed were obtained. Motion pictures were obtained for all conditions tested and form a supplement to this paper.

RESULTS

A typical time-history record, on which the various traces have been identified in detail, has been reproduced in figure 6. Records of each of the test runs have been reproduced in the following figures:

Model	Wave height (in.)	Speed (fps)	Record	Figure
272	3.5	15.1	212	7(a)
		23.2	213	7(b)
		30.2	216	7(c)
		37.0	248	7(d)
	4.5	15.2	219	8(a)
		23.2	220	8(b)
		30.2	224	8(c)
		37.0	248	8(d)
273	3.5	14.7	139	9(a)
		23.1	181	9(b)
		30.3	182	9(c)
		37.0	185	9(d)
	4.5	15.1	174	10(a)
		23.2	175	10(b)
		30.0	178	10(c)
		37.0	185	10(d)

Calibrations for the various traces have been indicated on these records. The position on the wave can be determined by the method described in the appendix.

From the records, the maximum acceleration for each accelerometer, together with the simultaneous readings of the trim, vertical position or rise, and acceleration for the other accelerometer have been determined and are tabulated in tables I and II. In these tables maximum and minimum values of trim and rise with simultaneous rise and trim, respectively, are tabulated.

The maximum positive and negative accelerations recorded for both models are plotted against speed in figure 11; the maximum and minimum trim and rise are plotted in figure 12.

In order to avoid possible damage to the models, the maximum speed of 37 feet per second was not run in the $4\frac{1}{2}$ -inch wave.

At all speeds the records indicate that the models followed the motions of the waves, and accelerations became greater as the speed increased. The motions in trim and rise tended to decrease with

increase in speed. A detailed analysis of the records appears necessary before definite conclusions can be drawn as to the relative merits of the two designs in rough water.

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APPENDIX A

PROCEDURE FOR LOCATING THE MODEL RELATIVE TO WAVES

SYMBOLS

t_1	time between consecutive wave crests at forward wave strut, sec
t_2	time between same wave crest at forward and aft wave struts, sec
t_3	time between wave crest at forward wave strut and impact, sec
V_c	carriage speed, fps
V_r	relative speed between carriage and wave crest, fps
V_w	wave speed, fps
L	wave length, ft
d_s	distance between forward and aft wave struts (28.1), ft
d_m	distance from forward wave strut to model staff, ft
d_w	distance from forward wave strut to wave crest, ft
d	distance from wave crest to model staff, ft

PROCEDURE USING FORWARD AND AFT WAVE TRACES

The values for t_1 , t_2 , t_3 , and V_c are obtained directly from the oscillograph records. (See fig. 13.) The value d_m consists of a fixed dimension plus the fore-and-aft position of the staff on the fore-and-aft gear. This fixed dimension is 19.6 feet measured from the front wave strut to the model staff at the zero position on the fore-and-aft gear. The fore-and-aft position is obtained from the record. The relative speed between the carriage and the wave crest is

$$V_r = \frac{d_s}{t_2}$$

and the wave length is

$$L = \frac{t_1 d_s}{t_2}$$

The wave speed is

$$\begin{aligned} V_w &= V_r - V_c \\ &= \frac{d_s}{t_2} - V_c \end{aligned}$$

The distance from the forward wave strut to the wave crest is

$$d_w = V_r t_3$$

Hence, the location of the model staff with respect to the wave crest is

$$\begin{aligned} d &= d_m - d_w \\ &= d_m - V_r t_3 \\ &= d_m - \frac{d_s}{t_2} t_3 \end{aligned}$$

PROCEDURE USING THE FORWARD WAVE TRACE ONLY

The relative speed between the carriage and wave crest is

$$V_r = V_c + V_w$$

On the basis of data where traces were obtained with both wave struts, V_w is approximately 10.5 feet per second for waves $3\frac{1}{2}$ inches high and 23.5 feet long and V_w is approximately 9.7 feet per second for waves $4\frac{1}{2}$ inches high and 17.5 feet long.

The distance from the forward wave strut to the wave crest is

$$d_w = V_r t_3$$

and the location of the model staff with respect to the wave crest is

$$d = d_m - d_w$$

REFERENCE

1. Truscott, Starr: The Enlarged N.A.C.A. Tank, and Some of Its Work.
NACA TM 918, 1939.

TABLE I

DATA OBTAINED DURING RUNS IN WAVES
LANGLEY TANK MODEL 272

All values are model size

Record no.	Wave height (in.)	Wave length (ft)	Speed (fps)	Max. $\dot{\alpha}$ aft accel. (g)	Simult. values			Max. $\dot{\alpha}$ aft accel. (g)	Simult. values			Max. $\dot{\alpha}$ aft accel. (g)	Simult. values			Max. $\dot{\alpha}$ aft accel. (g)	Simult. values		
					$\dot{\alpha}$ fwd. accel. (g)	τ (deg)	r (in.)		$\dot{\alpha}$ fwd. accel. (g)	τ (deg)	r (in.)		$\dot{\alpha}$ fwd. accel. (g)	τ (deg)	r (in.)		$\dot{\alpha}$ fwd. accel. (g)	τ (deg)	r (in.)
212	3.5	24.0	15.1	0.2	0.2	4.8	-1.2	0.2	0.2	4.8	-1.2	-0.3	-0.4	7.7	4.3	-0.4	-0.3	7.7	4.3
213	3.5	23.7	23.2	1.0	1.3	.8	2.2	1.3	1.0	.8	2.2	-.7	-.8	5.2	5.6	-.8	-.7	5.2	5.6
216	3.5	24.0	30.2	3.0	3.1	1.4	1.3	3.1	3.0	1.4	1.3	-1.0	-1.0	1.6	3.3	-1.0	-1.0	1.6	3.3
248	3.5	22.6	37.0	3.8	3.8	1.1	1.4	3.8	3.8	1.1	1.4	-1.0	-1.0	1.1	3.4	-1.0	-1.0	1.1	3.4
219	4.5	17.5	15.2	.8	1.3	2.3	1.0	1.3	.8	2.3	1.0	-.6	-.7	7.2	4.4	-.7	-.6	7.2	4.4
220	4.5	17.4	23.2	1.4	2.0	5.8	1.4	2.0	1.4	5.8	1.4	-.7	-.8	4.0	3.6	-.8	-.7	4.0	3.6
224	4.5	17.5	30.2	1.8	1.6	1.9	1.2	1.6	1.8	1.9	1.2	-.8	-.9	2.9	3.6	-.9	-.8	2.9	3.6

Record no.	Max. $\dot{\alpha}$ (deg)	Simult. r (in.)	Min. $\dot{\alpha}$ (deg)	Simult. r (in.)	$\Delta \tau$ at max. $\dot{\alpha}$ for $\frac{1}{2}$ cycle (deg)	Max. $\dot{\alpha}$ (in.)	Simult. τ (deg)	Min. $\dot{\alpha}$ (in.)	Simult. τ (deg)	$\Delta \tau$ at max. $\dot{\alpha}$ for $\frac{1}{2}$ cycle (in.)
212	9.0	2.9	2.1	0.2	6.9	4.3	7.6	-1.2	4.8	5.5
213	7.0	4.4	.2	1.1	6.8	5.7	6.4	-.2	2.2	5.9
216	6.5	4.4	.8	1.6	5.4	5.8	5.4	.4	2.1	5.2
248	5.2	1.8	-.9	2.0	6.1	5.6	3.7	.4	1.6	4.5
219	9.5	3.6	1.7	.6	7.8	4.9	8.2	-.5	4.3	5.4
220	6.2	4.0	1.7	1.3	4.3	4.8	6.0	1.0	2.6	3.8
224	5.0	3.0	.7	1.8	4.2	4.3	4.6	.9	1.9	3.1

TABLE II

DATA OBTAINED DURING RUNS IN WAVES
LANGLEY TANK MODEL 273

All values are model size

Record no.	Wave height (in.)	Wave length (ft)	Speed (fps)	Max. $\dot{\alpha}$ aft accel. (g)	Simult. values			Max. $\dot{\alpha}$ aft accel. (g)	Simult. values			Max. $\dot{\alpha}$ aft accel. (g)	Simult. values			Max. $\dot{\alpha}$ aft accel. (g)	Simult. values		
					$\dot{\alpha}$ fwd. accel. (g)	τ (deg)	r (in.)		$\dot{\alpha}$ fwd. accel. (g)	τ (deg)	r (in.)		$\dot{\alpha}$ fwd. accel. (g)	τ (deg)	r (in.)		$\dot{\alpha}$ fwd. accel. (g)	τ (deg)	r (in.)
139	3.5	22.9	14.7	0.2	0.2	7.2	-1.5	0.2	0.2	7.2	-1.5	-0.3	-0.3	6.8	3.7	-0.3	-0.3	6.8	3.7
181	3.5	23.5	23.1	.6	.4	5.5	.2	.9	.3	3.1	.9	-.5	-.7	6.5	4.6	-.7	-.5	6.5	4.6
182	3.5	23.5	30.3	1.5	2.4	3.4	2.0	2.4	1.5	3.4	2.0	-.7	-.8	6.4	5.4	-.8	-.7	6.4	5.4
185	3.5	23.5	37.0	2.3	3.4	3.3	2.7	3.4	2.3	3.3	2.7	-.8	-.8	4.2	3.8	-.8	-.8	4.2	3.8
174	4.5	17.5	15.1	.3	.2	6.8	-.3	.3	0	2.2	.1	-.3	-.3	5.7	2.5	-.3	-.3	5.7	2.5
175	4.5	17.5	23.2	1.0	1.9	3.7	-.9	1.9	1.0	3.7	-.9	-.6	-.7	6.6	4.0	-.7	-.6	6.6	4.0
178	4.5	17.5	30.0	2.3	3.5	4.6	2.3	3.5	2.3	4.6	2.3	-.7	-.8	6.0	4.1	-.8	-.7	6.0	4.1

Record no.	Max. $\dot{\alpha}$ (deg)	Simult. r (in.)	Min. $\dot{\alpha}$ (deg)	Simult. r (in.)	$\Delta \tau$ at max. $\dot{\alpha}$ for $\frac{1}{2}$ cycle (deg)	Max. $\dot{\alpha}$ (in.)	Simult. τ (deg)	Min. $\dot{\alpha}$ (in.)	Simult. τ (deg)	$\Delta \tau$ at max. $\dot{\alpha}$ for $\frac{1}{2}$ cycle (in.)	Stabiliser setting (in.)	Air pressure (lb)
139	9.6	1.7	1.9	0	7.1	4.5	7.3	-2.0	5.0	5.5	0	0
181	9.3	3.9	3.5	.6	5.8	5.2	8.2	-.2	4.2	5.4	1.0	36.0
182	8.9	5.2	3.0	1.2	5.9	6.0	8.0	.6	4.0	5.1	1.1	37.0
185	8.3	5.9	3.0	2.0	5.1	6.6	7.5	1.1	3.8	4.8	1.5	50.0
174	9.1	1.8	2.0	.3	7.1	3.1	6.8	-1.1	4.7	4.2	0	0
175	8.6	3.6	3.5	.7	5.1	4.5	7.7	.4	4.2	4.1	1.0	32.5
178	8.2	4.6	4.2	2.0	4.0	5.3	7.8	1.6	4.5	3.7	1.0	38.0

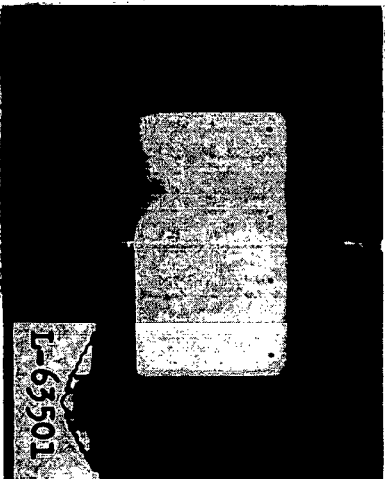
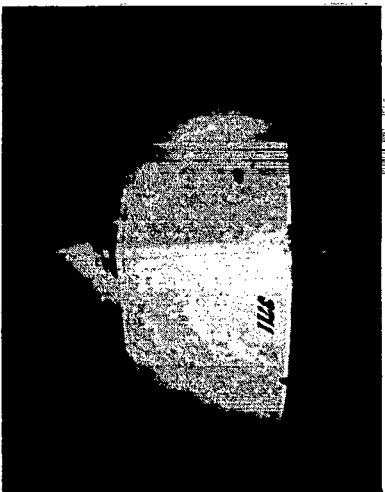
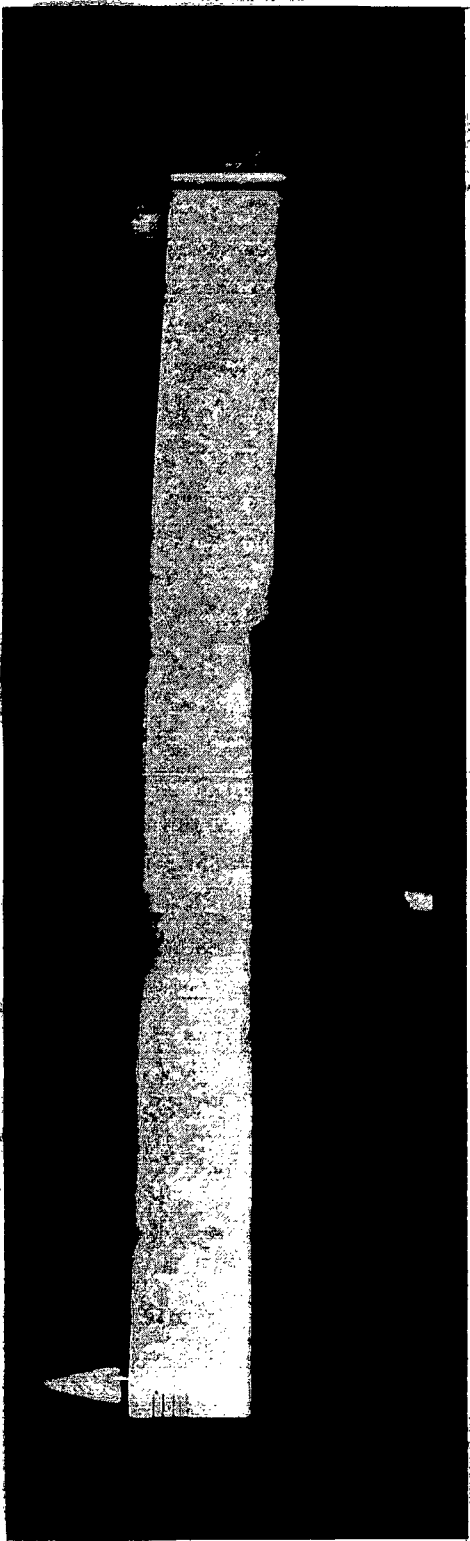


Figure 1.- Langley tank model 272, Vosper design.

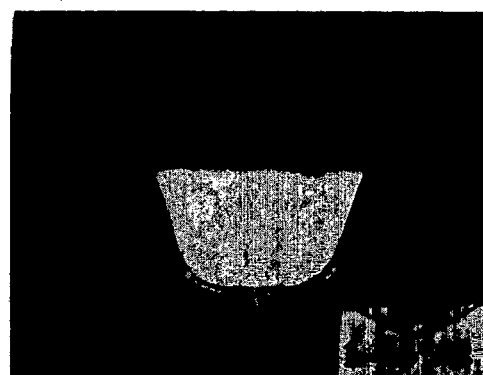
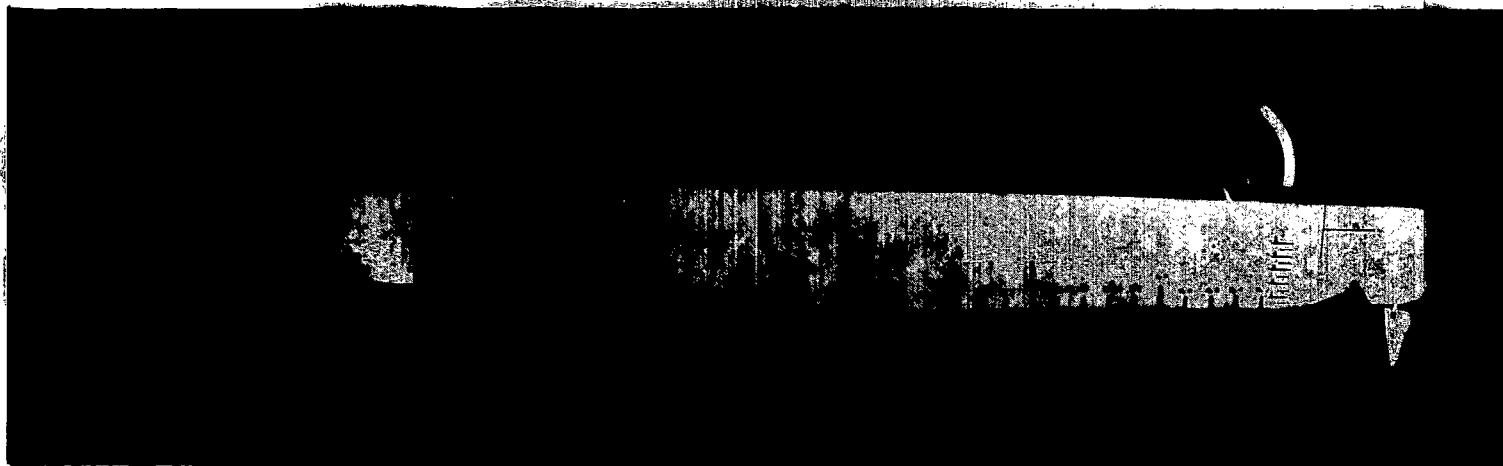
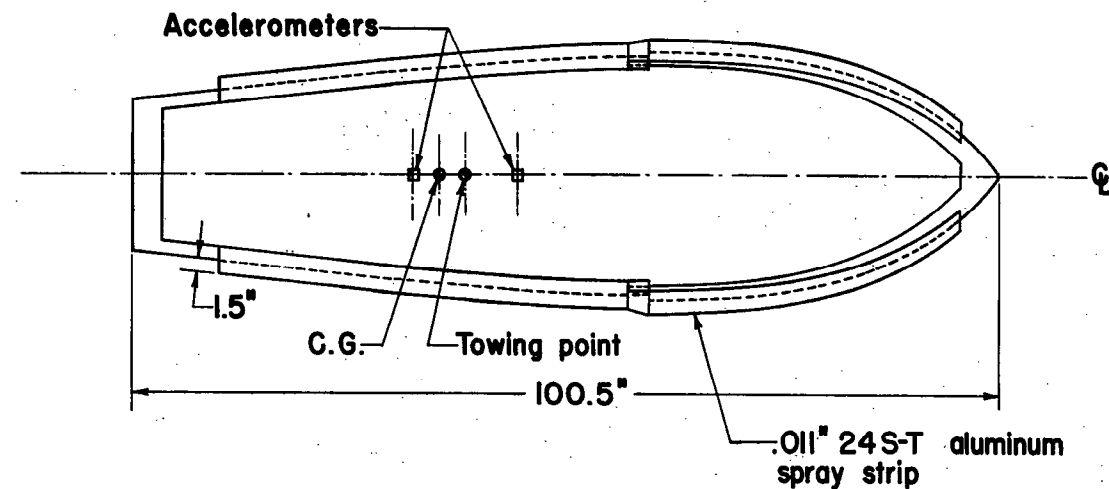


Figure 2.- Langley tank model 273, Plum design.



Note:

1. Station spacing: 9.88"
2. Base line coincides with inner bottom.

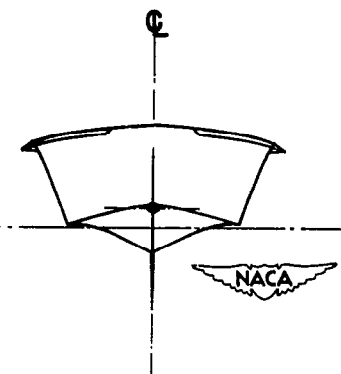
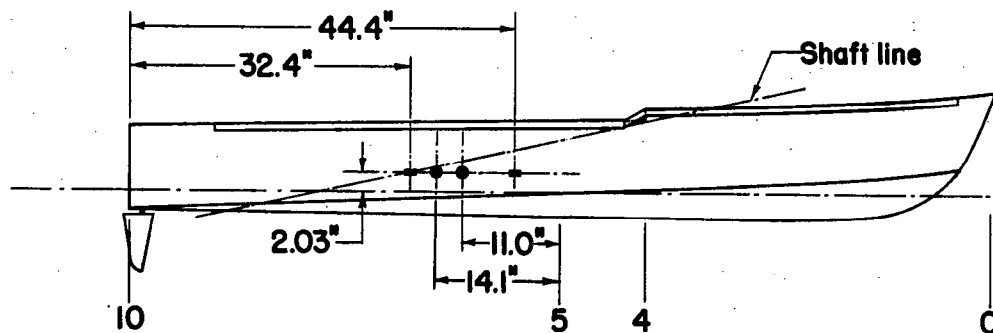


Figure 3.- General arrangement of Langley tank model 272.

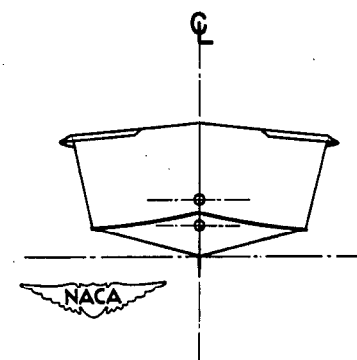
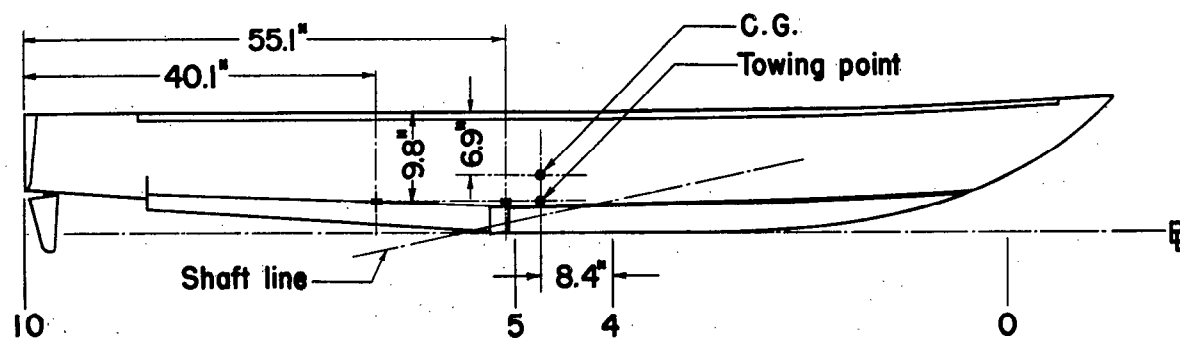
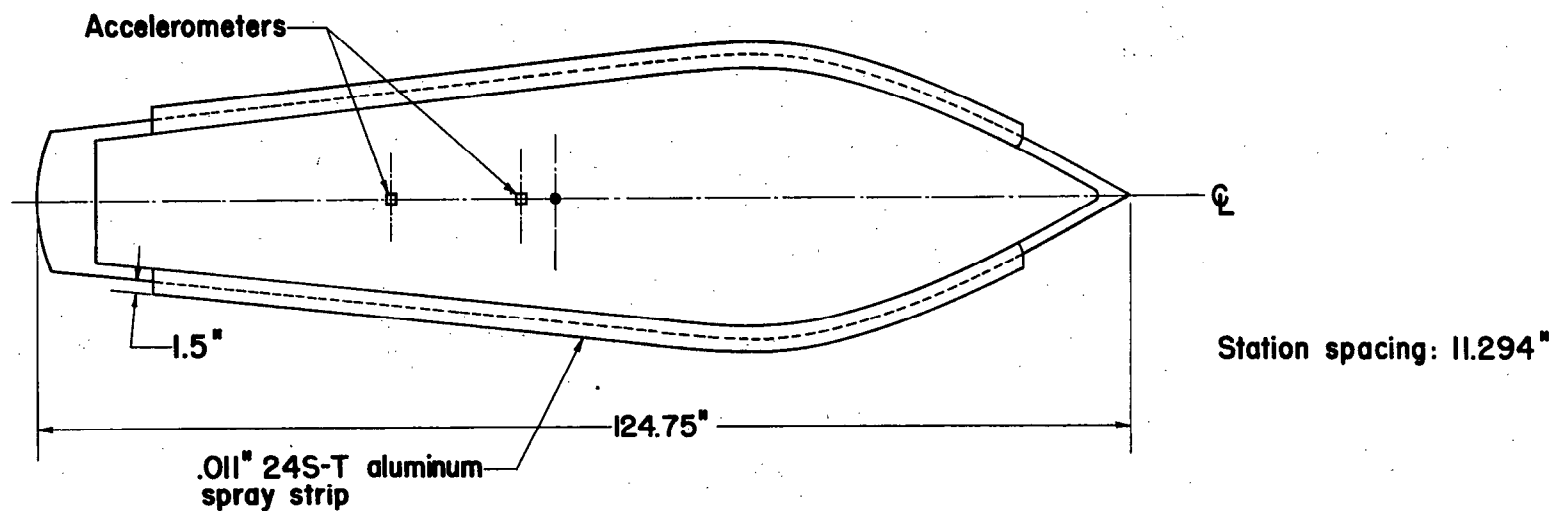


Figure 4.- General arrangement of Langley tank model 273.

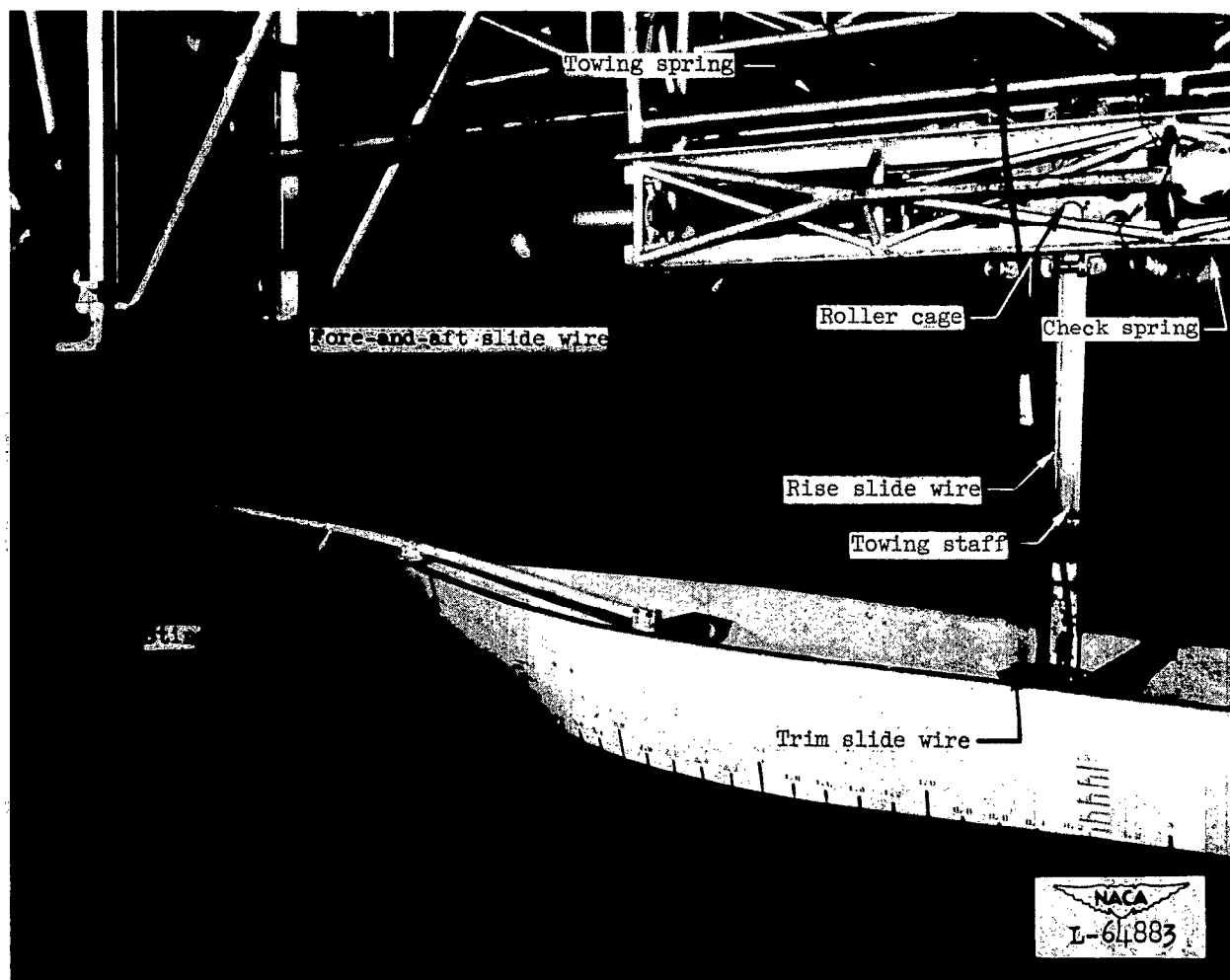


Figure 5.- Model setup and towing apparatus.

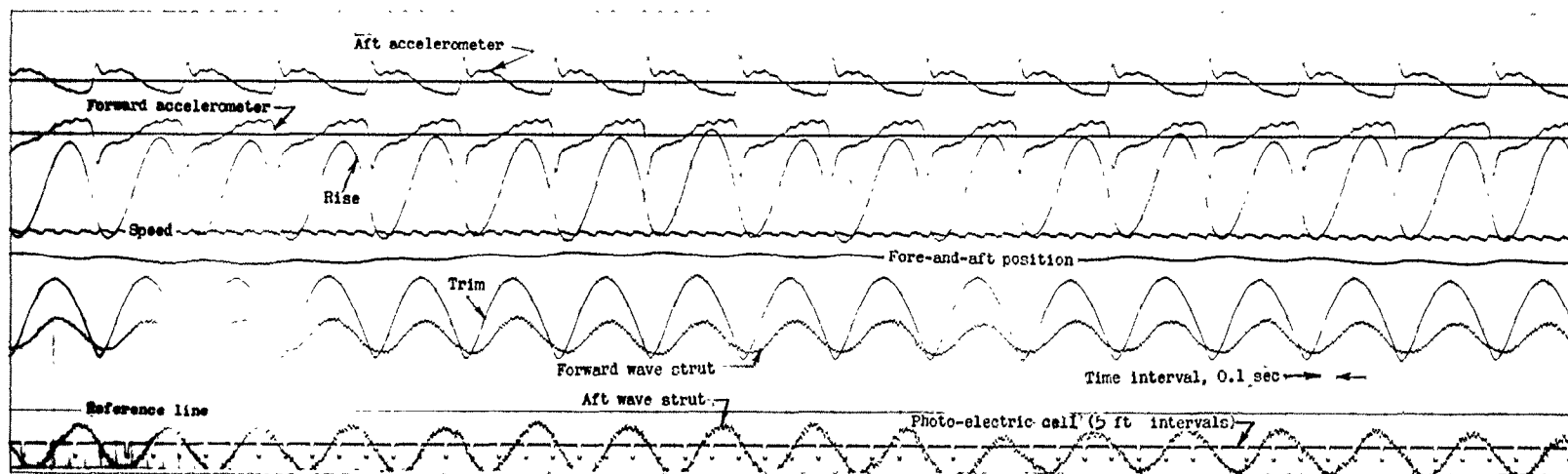
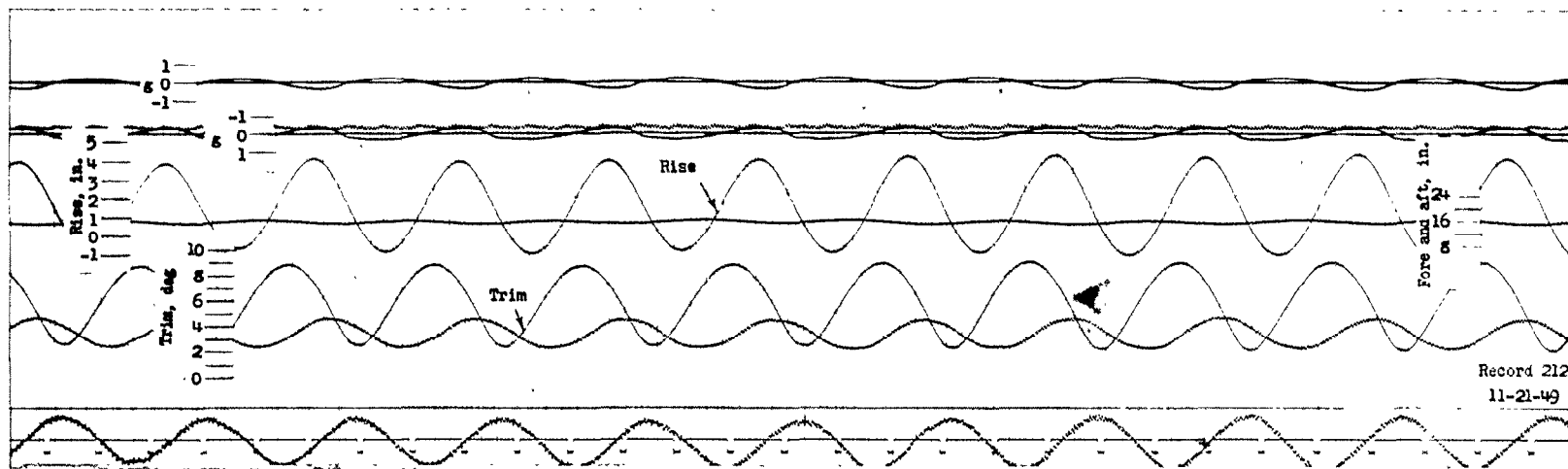
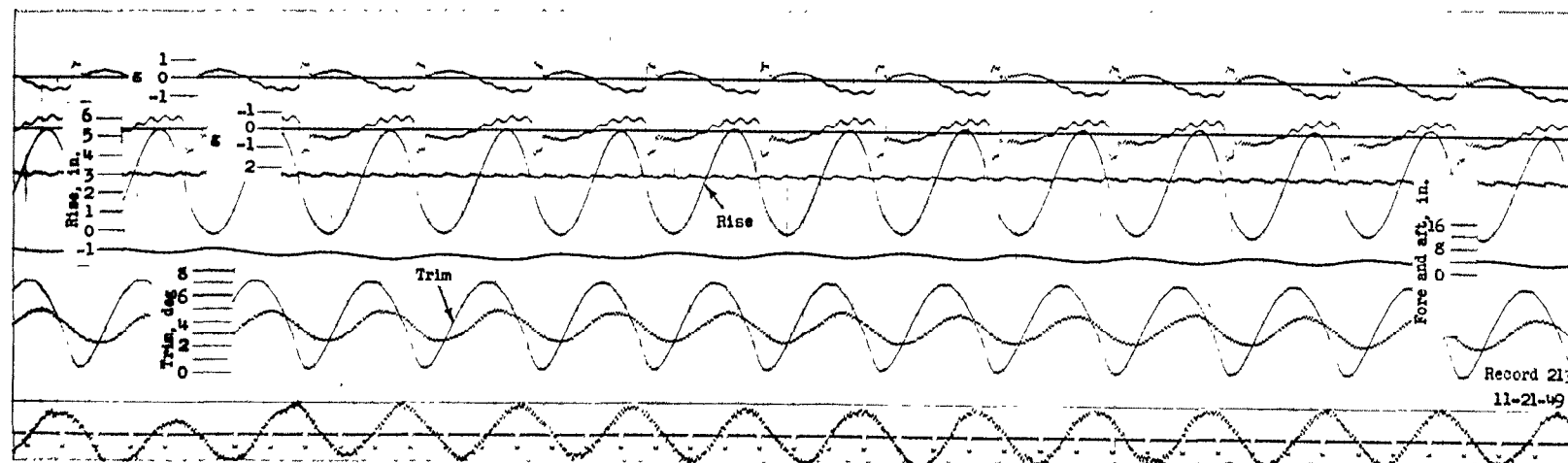


Figure 6.- Typical record.





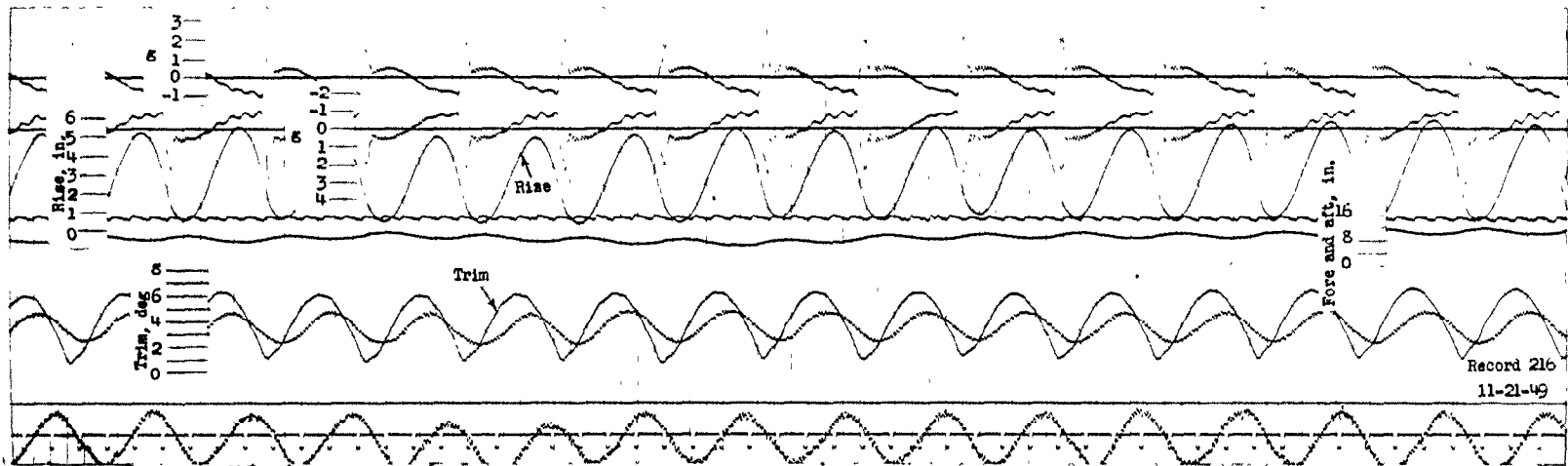
(a) Speed, 15.1 fps.



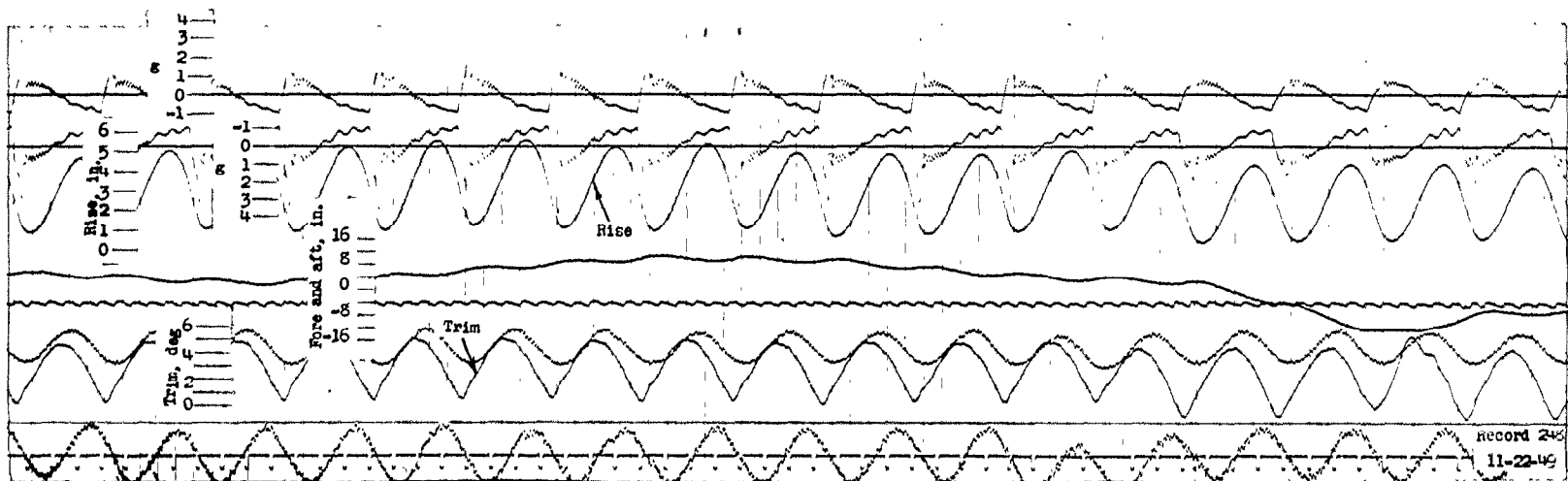
(b) Speed, 23.2 fps.



Figure 7.- Langley tank model 272, Vosper design. Waves, $3\frac{1}{2}$ inches high and 24 feet long.



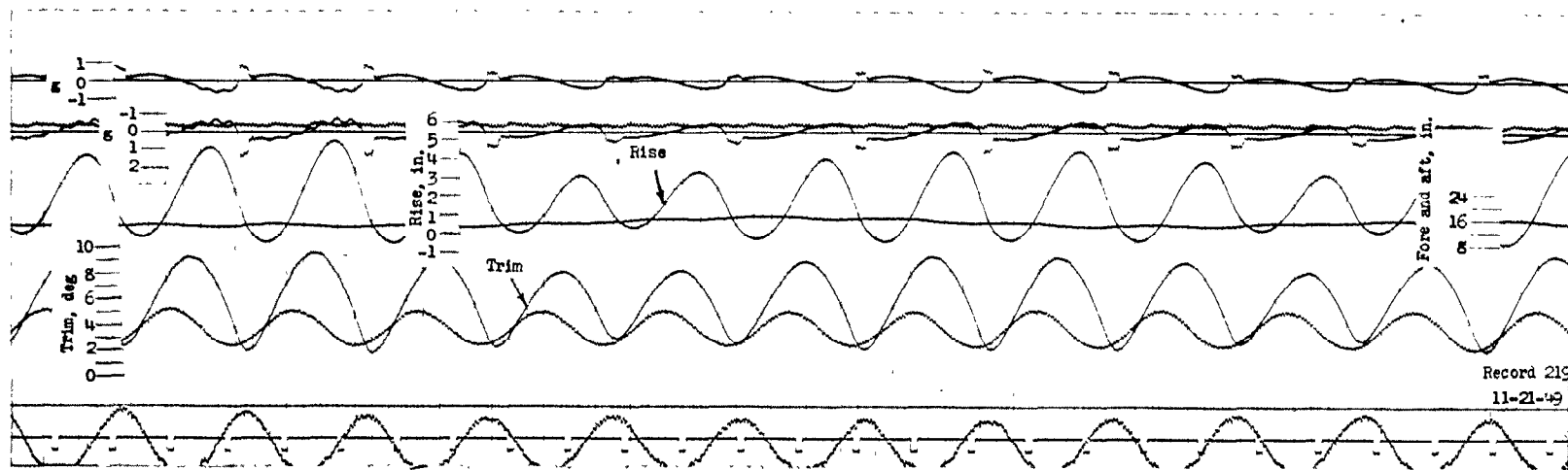
(c) Speed, 30.2 fps.



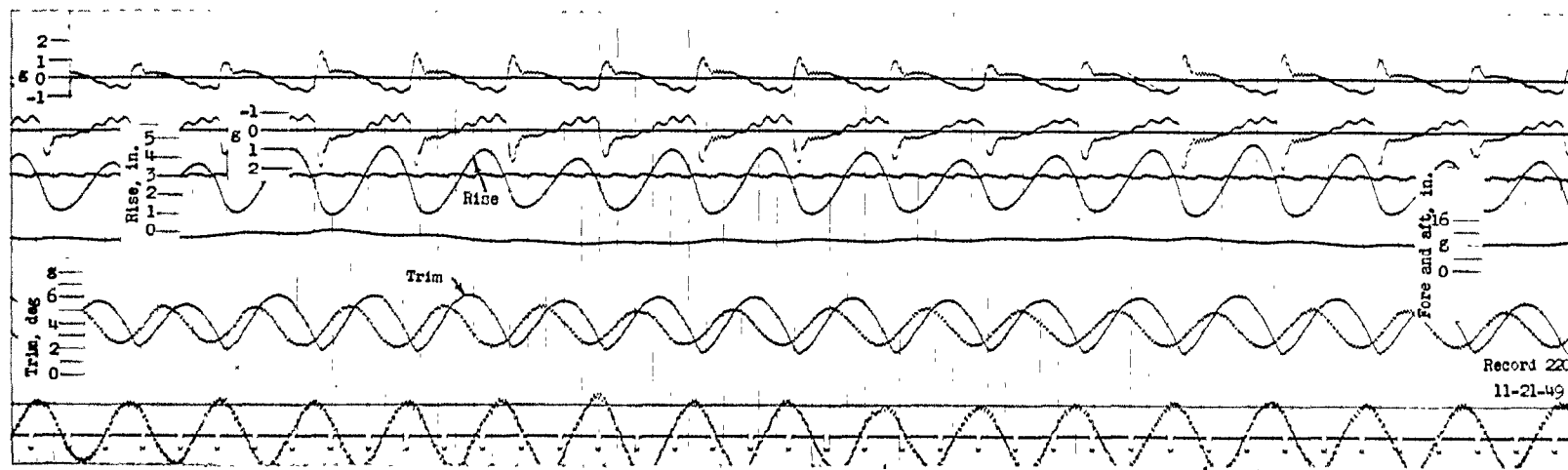
(d) Speed, 37.0 fps.



Figure 7.- Concluded.



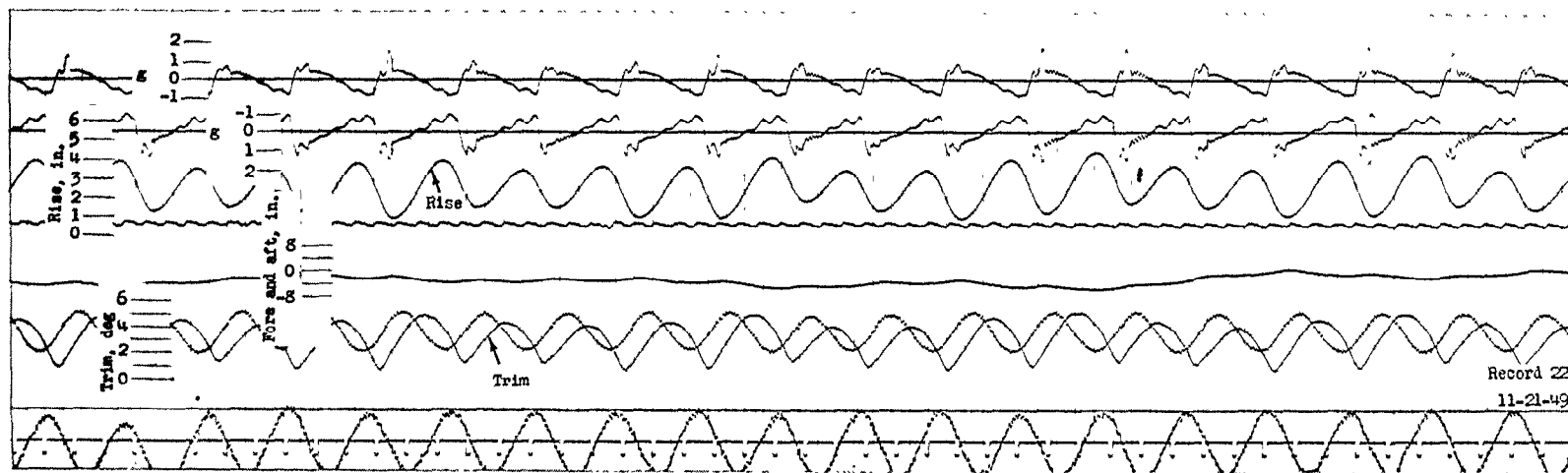
(a) Speed, 15.2 fps.



(b) Speed, 23.2 fps.



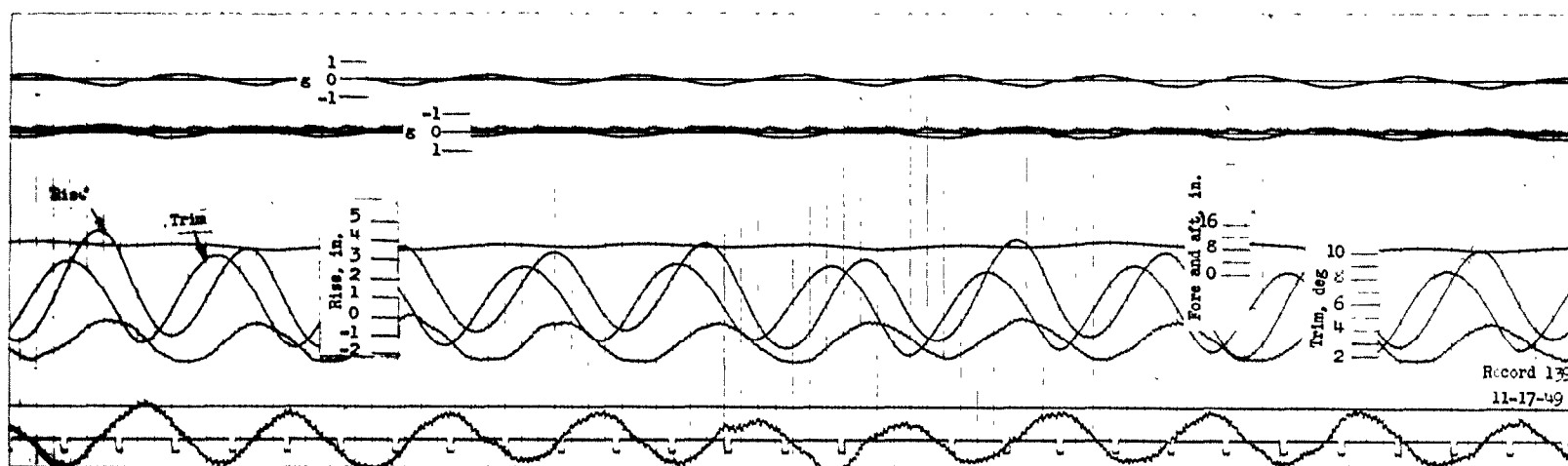
Figure 8.- Langley tank model 272, Vosper design. Waves, $4\frac{1}{2}$ inches high and 17 feet long.



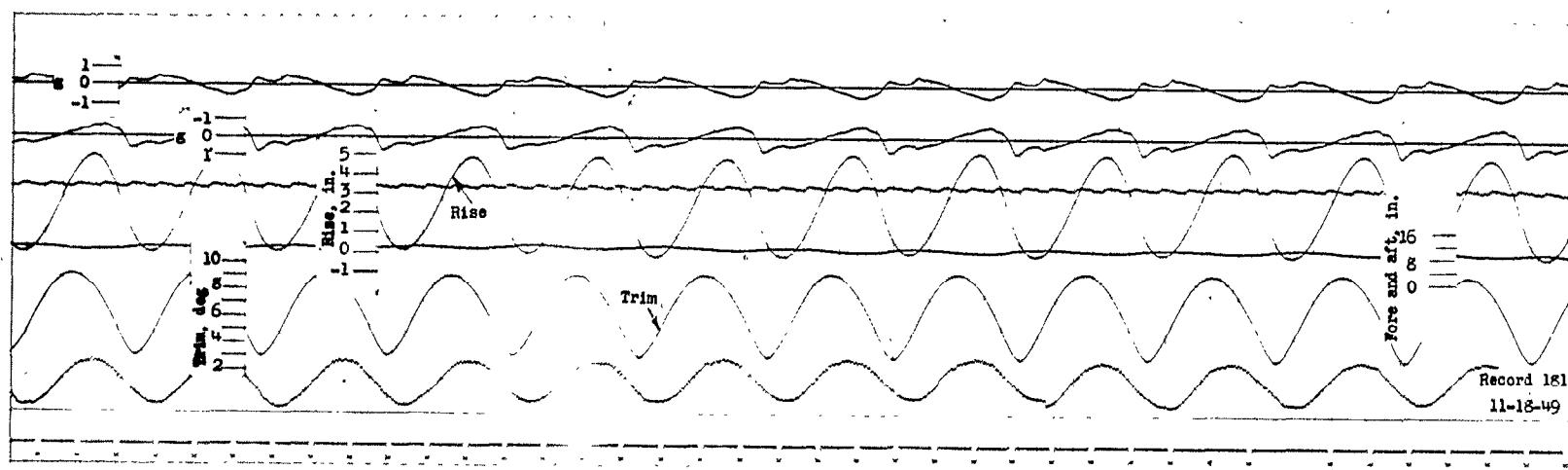
(c) Speed, 30.2 fps.



Figure 8.- Concluded.



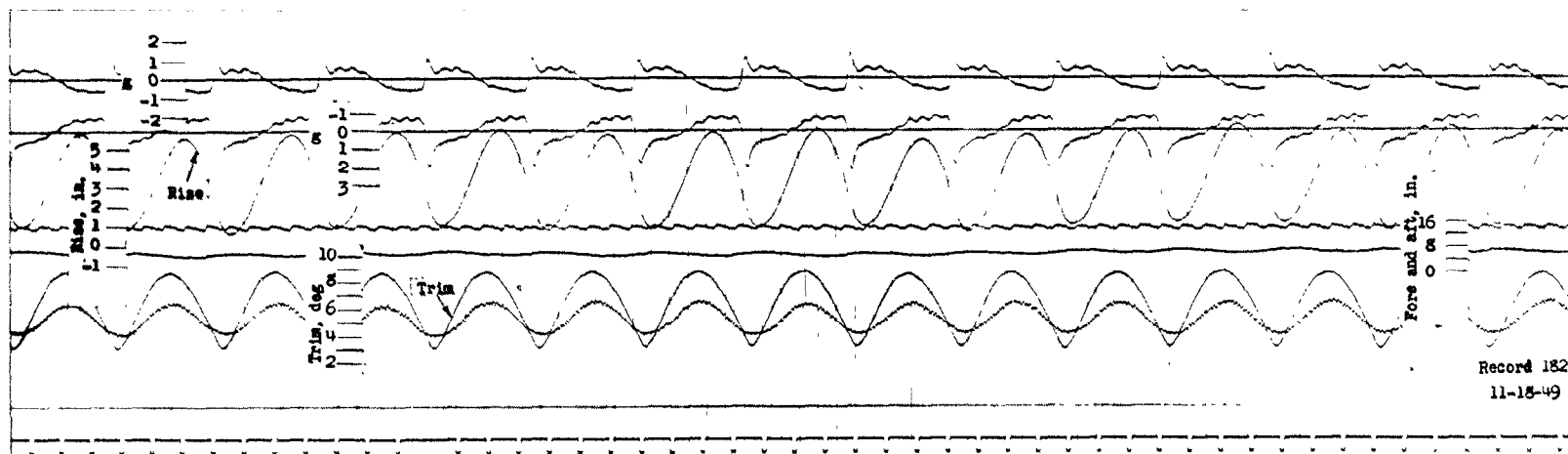
(a) Speed, 14.7 fps.



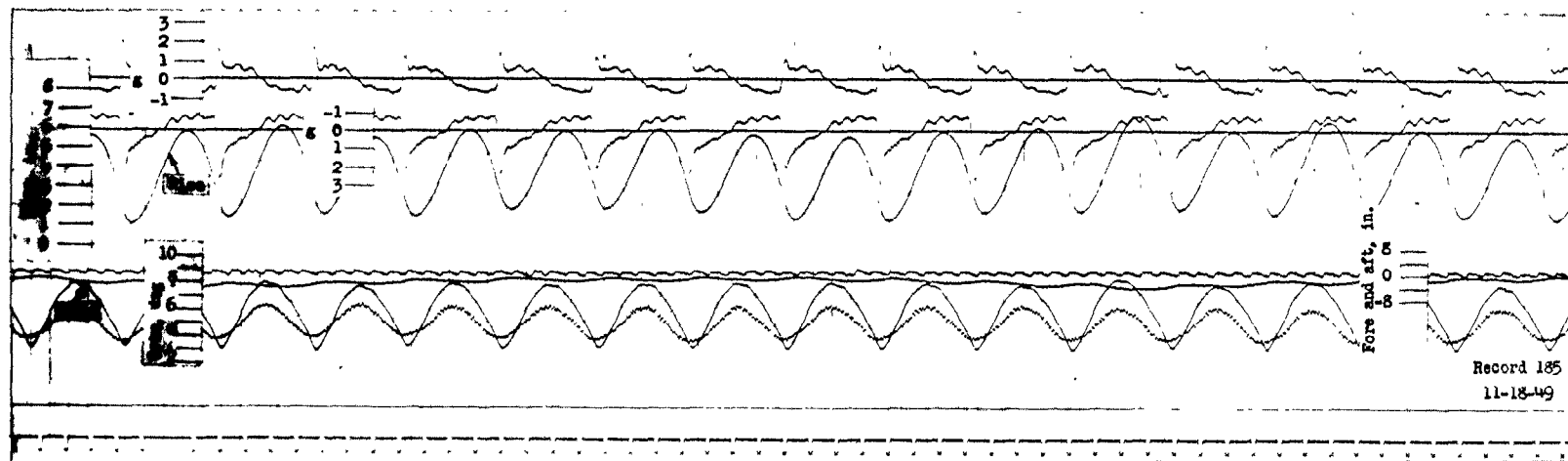
(b) Speed, 23.1 fps.



Figure 9.- Langley tank model 273, Plum design. Waves, $3\frac{1}{2}$ inches high and 24 feet long.



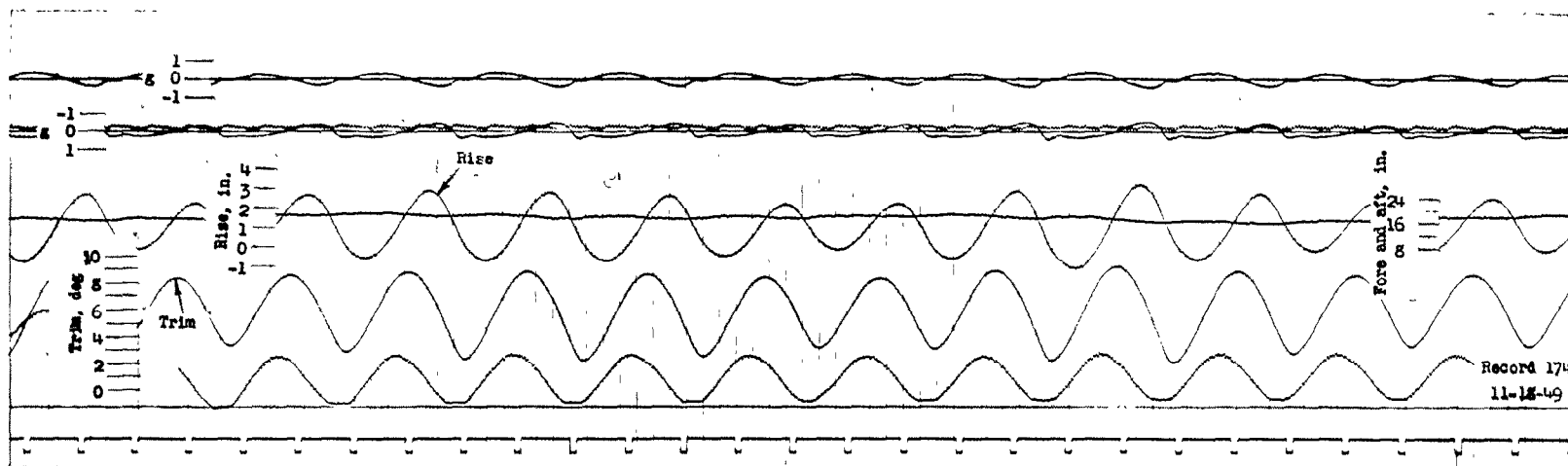
(c) Speed, 30.3 fps.



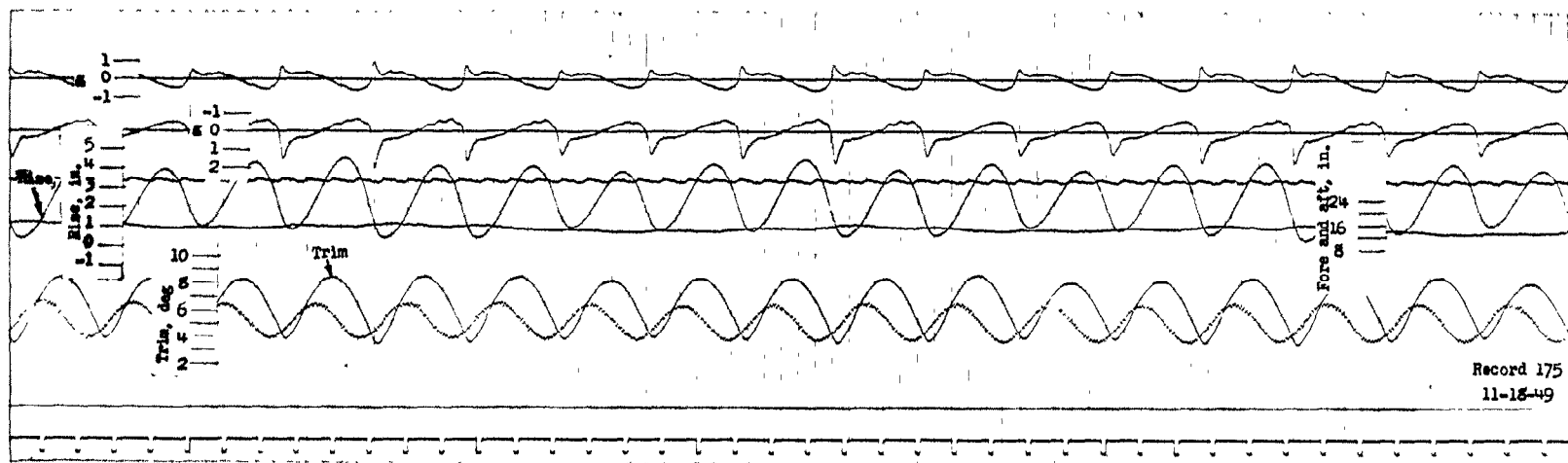
(d) Speed, 37.0 fps.



Figure 9.- Concluded.



(a) Speed, 15.1 fps.



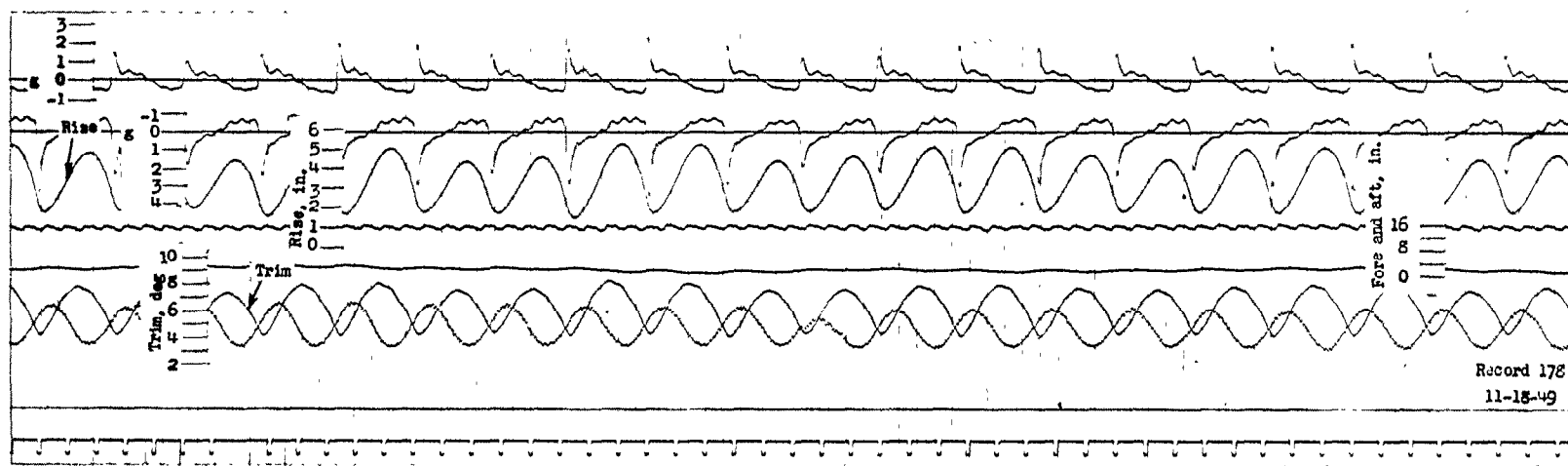
(b) Speed, 23.2 fps.



Figure 10.- Langley tank model 273, Plum design. Waves, $\frac{1}{2}$ inches high and 17 feet long.

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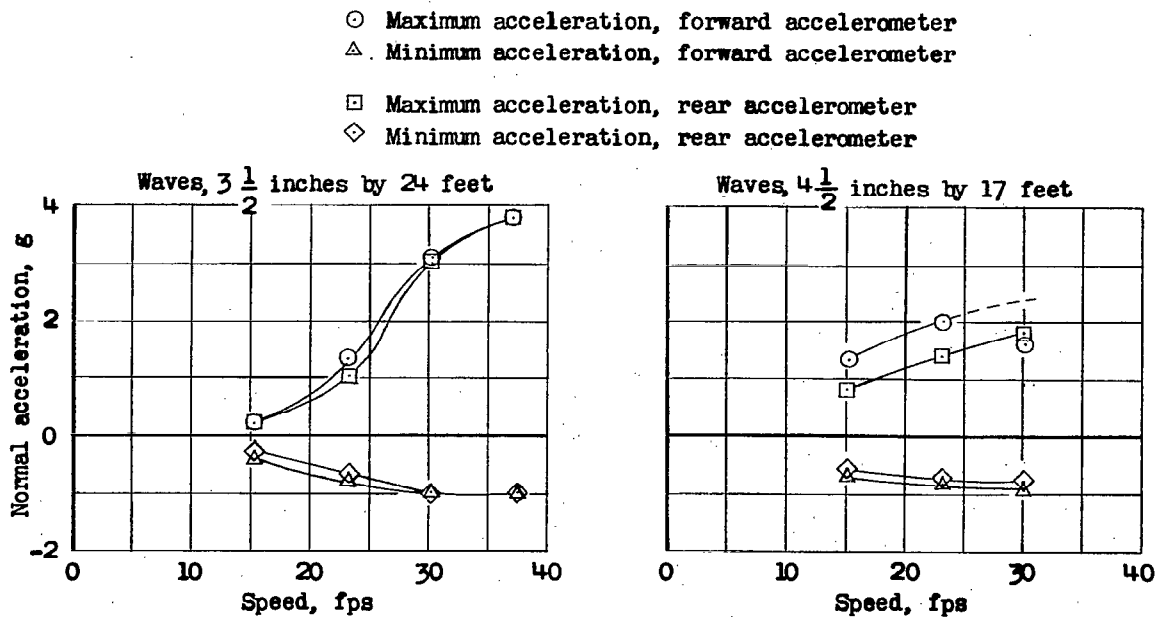
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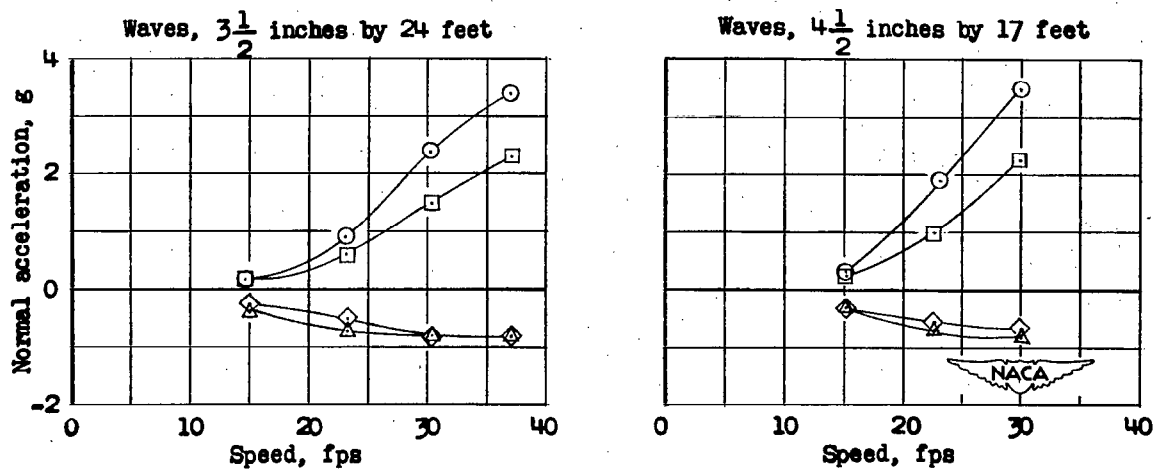
(c) Speed, 30.0 fps.



Figure 10.- Concluded.



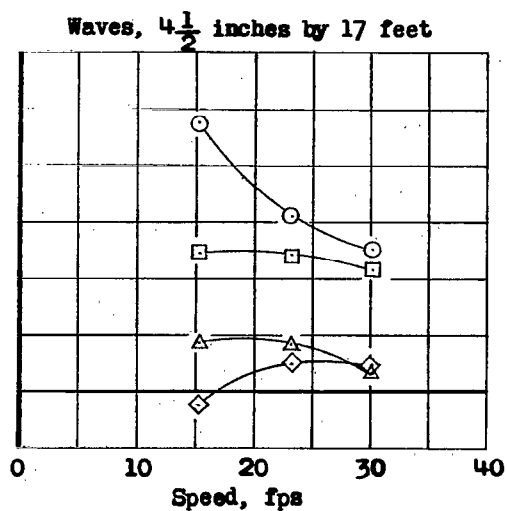
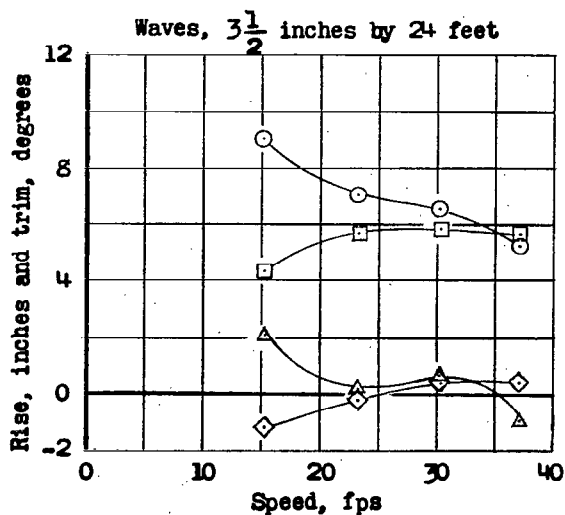
(a) Langley tank model 272, Vosper design.



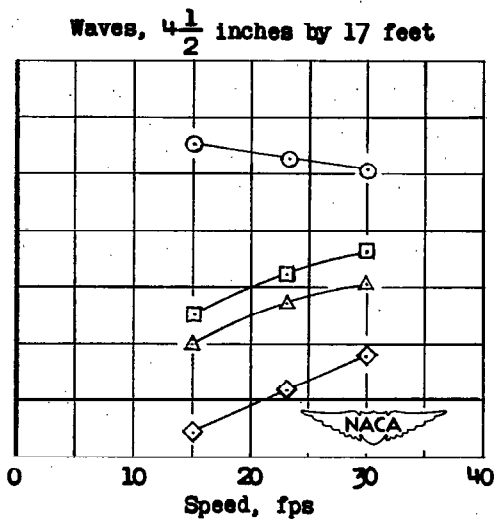
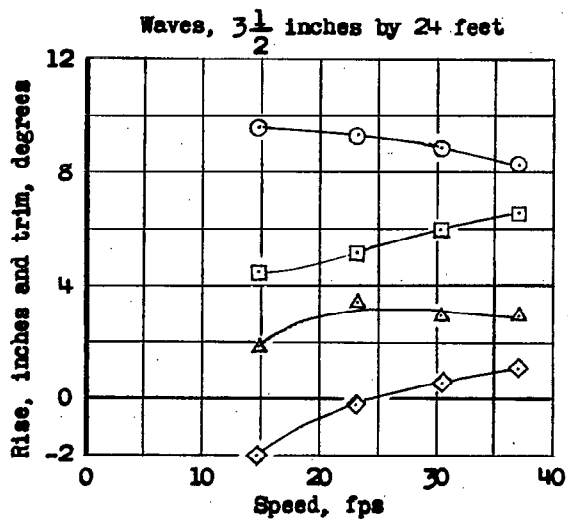
(b) Langley tank model 273, Plum design.

Figure 11.- Variation of maximum positive and maximum negative acceleration with speed in two wave sizes.

- Maximum trim
- △ Minimum trim
- Maximum rise
- ◇ Minimum rise

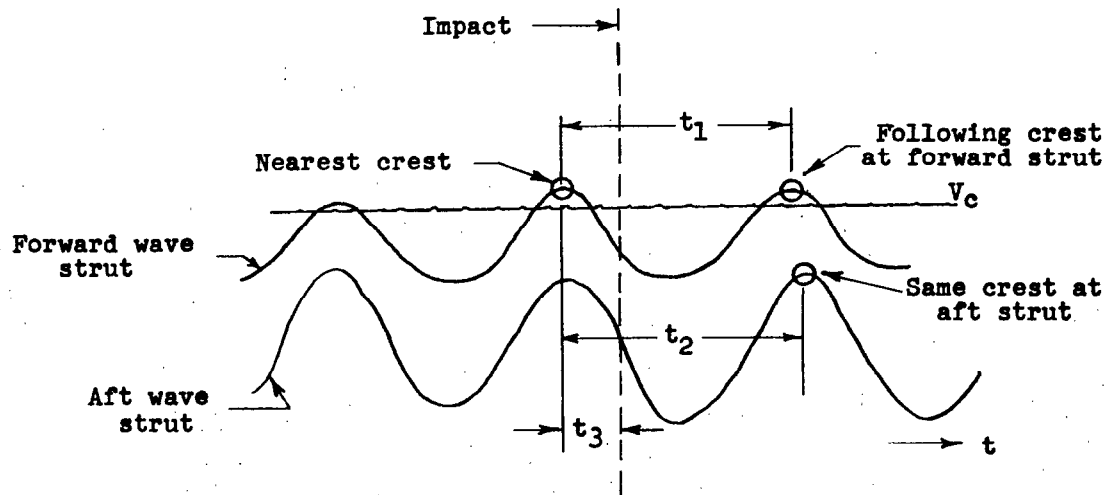


(a) Langley tank model 272, Vosper design.

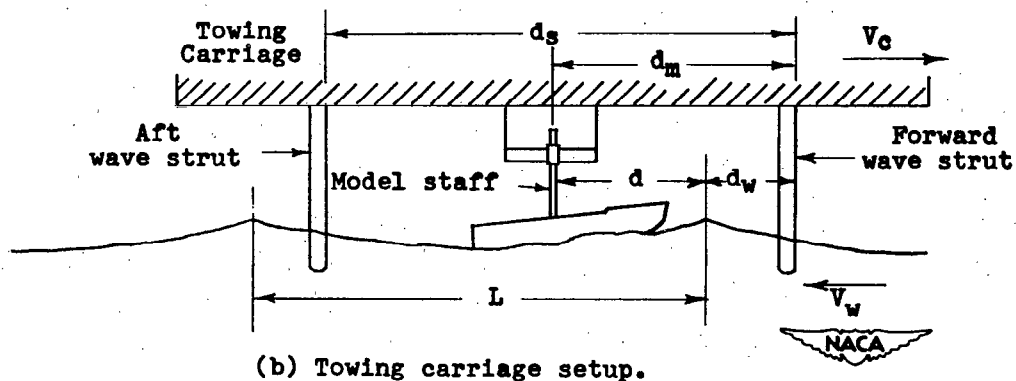


(b) Langley tank model 273, Plum design.

Figure 12.- Variation of maximum and minimum trim and rise with speed in two wave sizes.

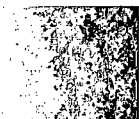


(a) Typical record.



(b) Towing carriage setup.

Figure 13.- Sketch for determining position of model on wave.



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